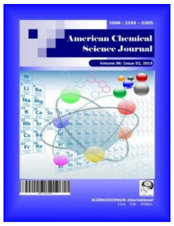

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Integrated Technology for Disposal of Chemical Waste

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Here a new decision how to convert hazardous substances into less harmful compounds is provided - an integrated technological scheme that will help to prevent from the risk of negative impact of the hazardous substances on the environment and people. Article concerns the probability of occurrence of environmental problems that may arise as a result of the storage in warehouses of chemicals classified as waste due to the occurrence of natural disasters such as flooding and earthquakes. These chemicals have an expiring date after which they are classified as hazardous waste. It is unacceptable to keep chemicals in landfills or sewage network as they may react with each other, and this would lead to irreversible consequences on the environment. After the chemical conversion by this integrated technological scheme the resultant compounds are salts that are safe. Spectral analysis of the products was carried out by IR spectrophotometer Hazmat, demonstrating the conversion of the hazardous materials into new chemical compounds. This new technological development can be used for chemical transformations of many other substances that are not mentioned in this article. The resulting compounds can be used as raw materials in many industries such as chemical, metallurgical, glass, textile and other industries.

Keywords: Neutralization; hazardous chemicals; inorganic substances; organic substances.

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1. INTRODUCTION

In 1998 is created the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. The need to create and are the incidents that occurred during the 80 years of the 20th century. One of these incidents was the so-called Khian Sea waste disposal incident, which took place in 1986 in the United States. The incident is related to improper disposal of ashes from incinerator the shores of Haiti [1-3].

Another similar incident is the transfer of hazardous chemicals from an Italian company to a Nigerian company in 1988 to store them for a small fee. As can be seen from these two cases in the past, developed countries deliver chemical waste to undeveloped countries in Africa without having the idea that they can lead to major ecological disaster and threaten human health [4].

In the 21st century hazardous waste is no longer transported to countries in Africa. In some European and American countries such waste is disposed by incineration, in other countries the waste is being closed in BB cubes or disposed in former salt mines. All these methods of treatment are ineffective. With the integrated technology that is resented in this article, the resulting substance can be used in various industries that are not related to food and drugs.

The chemicals are divided into two main groups: organic and inorganic chemicals. The element that is present in all organic compounds is carbon. An exception from this rule are compounds like CO (carbon monoxide), CO_2 (carbon dioxide), H_2CO_3 (carbonic acid) that are inorganic compounds [5,6]. All other compounds that do not contain carbon in their molecules are inorganic compounds such as HCl (hydrochloric acid), H_2SO_4 (sulphuric acid), H_3PO_4 (phosphoric acid), HNO_3 (nitrogen acid), HF (hydrofluoric acid), HNO_2 (nitrous acid), H_2SO_3 (sulphurous acid); metal hydroxides like NaOH (sodium hydroxide), KOH (potassium hydroxide), $Ca(OH)_2$ (calcium hydroxide) etc. [5,6]; hydroxides of metals - Sodium hydroxide NaOH, potassium hydroxide KOH, calcium bi hydroxide $Ca(OH)_2$; all inorganic salts such as Na_2CO_3, K_2CO_3; inorganic oxides like PbO, CuO [5,6].

Chemicals are used in manufacturing industry and research. In the manufacturing industry these chemicals can be also a byproduct of the process of manufacture. These chemicals have an expiring date after which there is a need for their environmentally disposal. Dumping chemicals in landfills or sewage network is unacceptable, as they may react with each other, and this would lead to irreversible consequences on the environment [7-9]. For that main reason chemicals with expired shelf life are classified as hazardous waste. Storage of these chemicals in warehouses is not safe, as these sites for storage might be affected by natural disasters (floods, earthquakes, fires, etc.) [7-9]. In case of flooding, certain chemicals that are stored in the warehouses can react with water. As a result of this chemical reaction explosive and toxic gases will emit in the atmosphere. Other chemicals can react with water thus leading to formation of hazardous solutions which can easily penetrate into the soil. This would lead to a significant increase in soil toxicity. In the event of an earthquake, there is a risk of mixing of the chemical substances that are stored in a warehouse. This could lead to a violent chemical reaction [6]. In relation to the examples provided here I have developed integrated technology for the disposal of hazardous chemicals (defined as waste) to chemicals with less hazardous properties. The main goal is through chemical conversion to transform the hazardous chemicals into less dangerous compounds, the latter substances may be recovered and to be used in industry [10-12].

2. TECHNOLOGICAL SCHEME OF TECHNOLOGY FOR DISPOSAL OF ORGANIC CHEMICALS

Fig. 1 represent a schematic diagram of the integrated technology for the disposal of organic chemicals.

The system consists of: A reactor with a stirrer and a heat exchanger, pumps, vessels A and B, level container for obtained substance, crystallizer, thermometers and device for capturing the off gas in case such gas is evaporated. Vessels A and B have a volume consistent with the process, depending on the required quantities of chemicals. The movement of the substances is carried out by an automated system of pumps, which are connected with level switches. Vessels A and B are located on the height required for the movement of chemicals by gravity to the reactor. A vessel with a volume, consistent with the amount of the resulting compounds, is fitted just below the reactor. When the resultant compound is in an aqueous solution, the substance is fed to the crystallizer, and then starts the process of crystallization. Depending on the nature of the substance and atmospheric parameters, the process is carried out under atmospheric conditions. Substances of low solubility in water form a precipitate, which should be filtered, and then the filtrate thus obtained was dried under atmospheric conditions or in an oven. Heat exchange apparatus is used to correct the temperature of the reactor, depending on the process: The reaction may occur in two directions with respect to temperature, respectively exothermic or endothermic reaction. The aim is not to change the desired end result, namely getting another compound. It is essential to maintain a constant temperature control in the reactor by a thermometer.

2.1 Chemicals after Process of Disposal

Two types of compounds that were obtained after disposal are discussed: hexamethylenetetramine and sodium acetate. The reactions take place according to the following equations:

Disposal of 37% aqueous formaldehyde solution with 25% ammonia solution, the reaction proceeds by the following equation:

$$6CH_2(OH)_2 + 4NH_4OH \rightarrow (CH_2)_6N_4 + 16H_2O$$

An aqueous solution of hexamethylenetetramine, after crystallization dry solid crystalline of $(CH_2)_6N_4$ is obtained.

Upon disposal of acetic acid with sodium bicarbonate, the reaction proceeds by the following equation:

$$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2\uparrow$$

As a result of the reaction, an aqueous solution of sodium acetate is formed, and after crystallization dry crystalline solid is obtained.

3. TECHNOLOGICAL SCHEME OF INTEGRATED TECHNOLOGY FOR DISPOSAL (NEUTRALIZATION) OF INORGANIC CHEMICALS

Fig. 2 represents the principal scheme of the integrated technology equipment for disposal (neutralization) of inorganic chemicals.

The equipment for disposal of organic chemicals can be used for disposal (neutralization) of inorganic chemicals as well. The difference is the

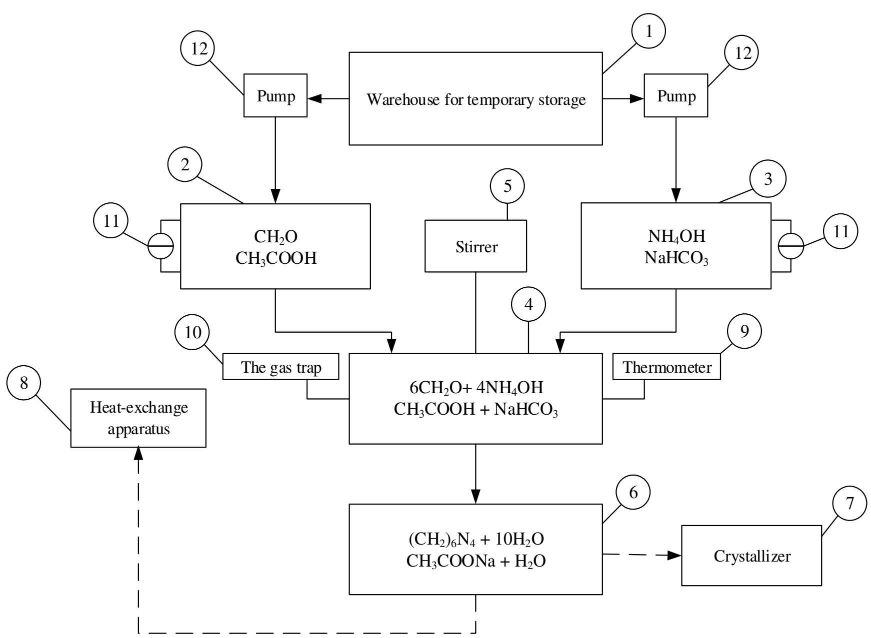

Fig. 1. Schematic diagram of equipment for the disposal of organic chemicals: 1. Warehouse for temporary storage, 2. Receptacle of substance A, 3. Receptacle of substance B, 4. A reactor for chemical conversion, 5. Stirrer, 6. Court for the resulting substance, 7. Crystallizer, 8. Heat-exchange apparatus, 9. Thermometer, 10. The gas trap, 11. Level meters, 12. Pumps

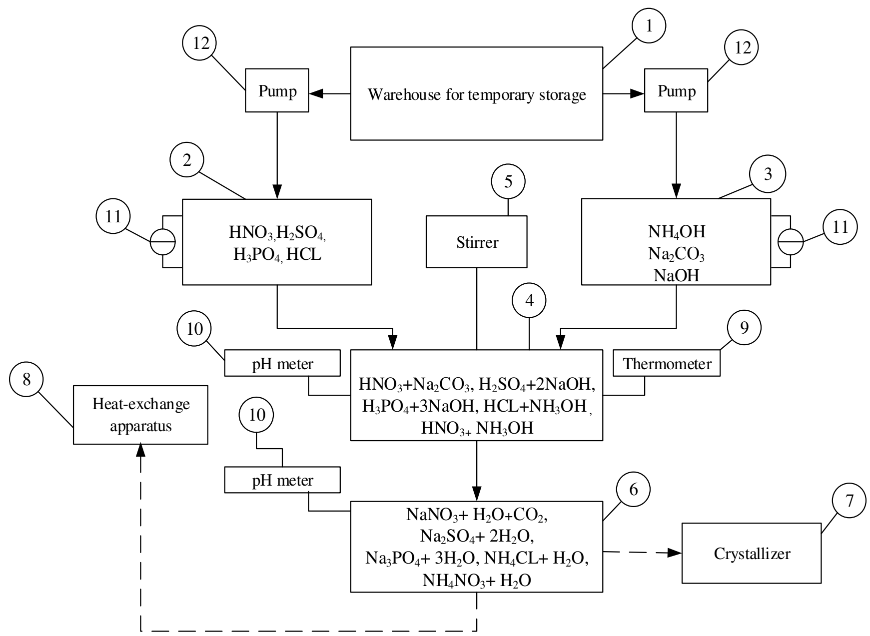

Fig. 2. Schematic diagram of the equipment for disposal of inorganic chemicals: 1. Warehouse for temporary storage, 2. Receptacle of substance A, 3. Receptacle of substance B, 4. A reactor for chemical conversion, 5. Stirrer, 6. Court for the resulting substance, 7. Crystallizer, 8. Heat-exchange apparatus, 9. Thermometer, 10. pH meter, 11. Level meters, 12. Pumps

necessity of device for control the hydrogen exponent which should be connected to the reactor at the site of gas acceptor, and to the receptacle for the resulting substance. During the process of disposal a continuous monitoring of the temperature is carried out by a thermometer, the hydrogen exponent of the medium by means of a pH meter is monitored as well. For some chemicals obtained after the chemical conversion, the hydrogen exponent changes slightly, it depends on the chemical nature of the resulting compound and could not be a reason not to assume that the process of disposal has failed. It is noted that some of the compounds obtained are with pH> 7, but for the bigger part of the resulting compounds pH = 6,5-7,5, and all the obtained compounds are salts.

4. TYPES OF CHEMICALS RECEIVED AFTER THE PROCESS OF DISPOSAL (NEUTRALIZATION)

In this part are considered six compounds obtained after neutralization: sodium nitrate, sodium sulfate, sodium phosphate, ammonium chloride, ammonium nitrate. The reactions take place according to the following equations:

$$2HNO_3+Na_2CO_3 \rightarrow 2NaNO_3+ H_2O+CO_2\uparrow$$

The resulting compound is sodium nitrate, which is a neutral character (with hydrogen exponent pH ≈ 7) and the filtrate is with slightly acidic character induced by the carbon dioxide in the water.

$$H_2SO_4+2NaOH \rightarrow Na_2SO_4+ 2H_2O$$

The resulting aqueous solution of sodium sulfate has neutral character with hydrogen exponent pH ≈ 7, after crystallization dry solid crystalline is obtained.

$$H_3PO_4+3NaOH \rightarrow Na_3PO_4+ 3H_2O$$

The resulting aqueous solution of odium phosphate is alkaline in nature with a hydrogen exponent pH ≈ 11, after crystallization the obtained compound is dry solid crystalline.

$$HCl+NH_4OH \rightarrow NH_4Cl+ H_2O$$

The resulting aqueous solution of ammonium chloride has a slightly acidic character with hydrogen exponent pH ≈ 5, after crystallization the resulting compound was dry solid crystalline.

$$HNO_{3+} NH_4OH \rightarrow NH_4NO_3+ H_2O$$

The resulting aqueous solution of ammonium nitrate has a slightly acidic character, hydrogen exponent pH ≈ 5, after crystallization the resulting compound was solid NH_4NO_3 dry crystal.

5. RESULTS AND DISCUSSION

The following figures (Figs. 3-7) represent the compounds obtained after the process of disposal:

When this integrated technology is used for the disposal of organic chemicals, $(CH_2)_6N_4$ and CH_3COONa were obtained. When the technology is used for disposal of inorganic chemicals the following compounds $NaNO_3$, Na_3PO_4, NH_4Cl and NH_4NO_3 were derived. The final substances were analyzed with an infrared spectrophotometer HazMatID Elite. The infrared spectrophotometer HazMatID Elite, operates on the principle of comparison of the spectrogram of the resulting compound with a database which is previously set in the spectrophotometer. Fig. 3, Fig. 4, Fig. 5, Fig. 6 and Fig. 7 represent spectrograms of the obtained substances: Sodium nitrate, hexamethylenetetramine (hexamine), sodium acetate, sodium sulfate and ammonium nitrate. Black and red curves correspond to the schedule of pre-set database in the spectrometer and to the resulting compound respectively. These spectrograms confirm that the processes of chemical conversion represented by the chemical equations were achieved and that the resulting substances are exactly the expected compounds as a result of the process of disposal.

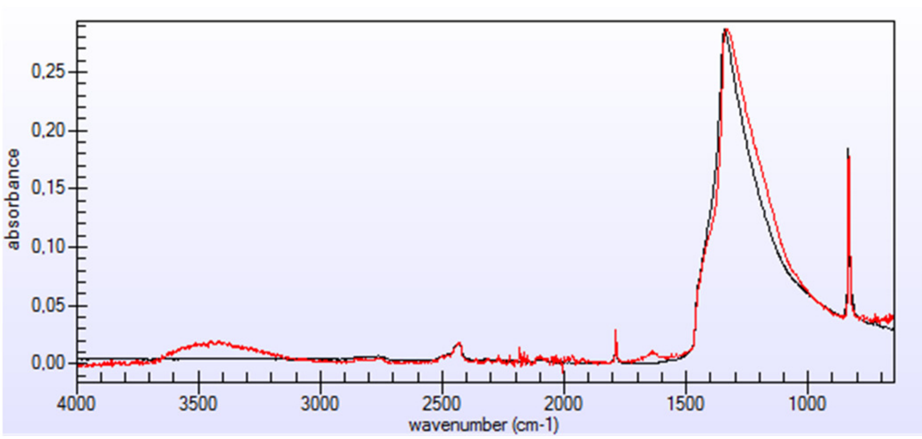

Fig. 3. Spectrogram of the resulting sodium nitrate after the process of neutralization

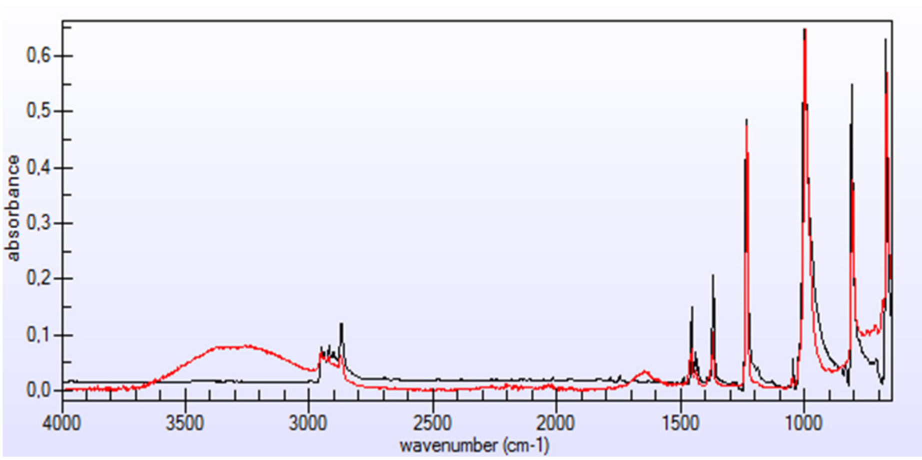

Fig. 4. Spectrogram of hexamethylenetetramine obtained after the process of neutralization

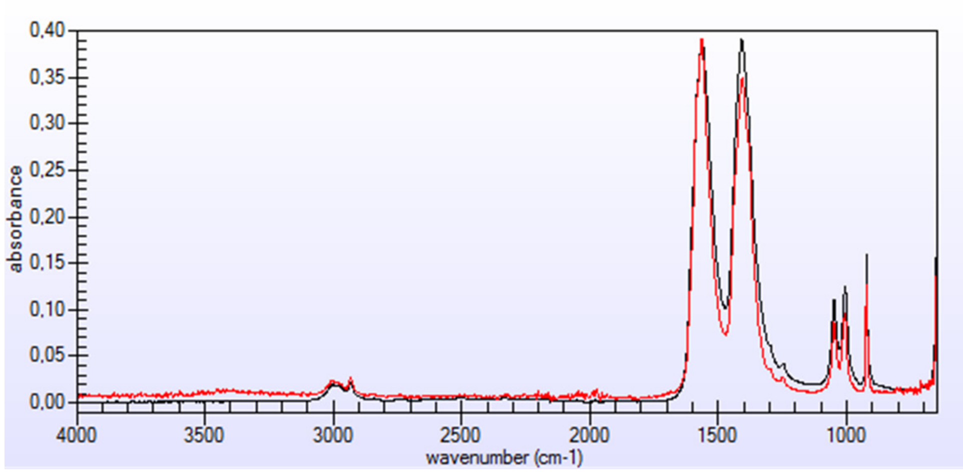

Fig. 5. Spectrogram of sodium acetate obtained after the process of neutralization

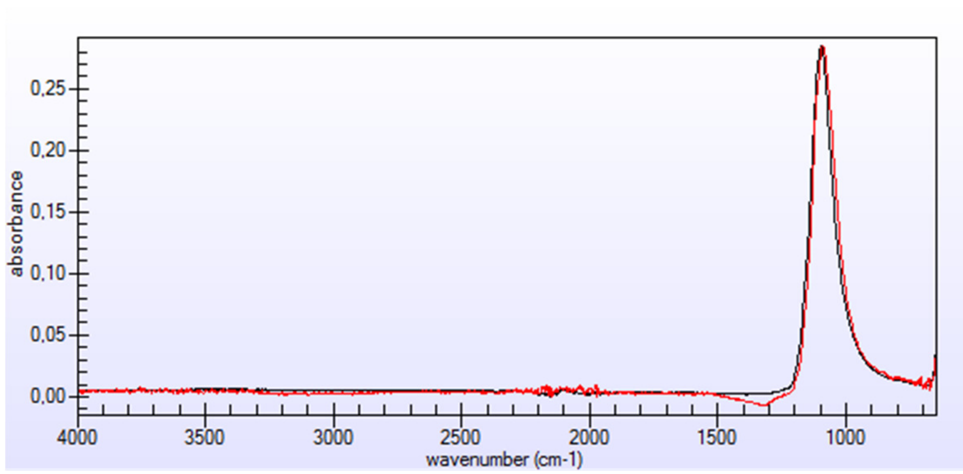

Fig. 6. Spectrogram of sodium sulfate obtained after the process of neutralization

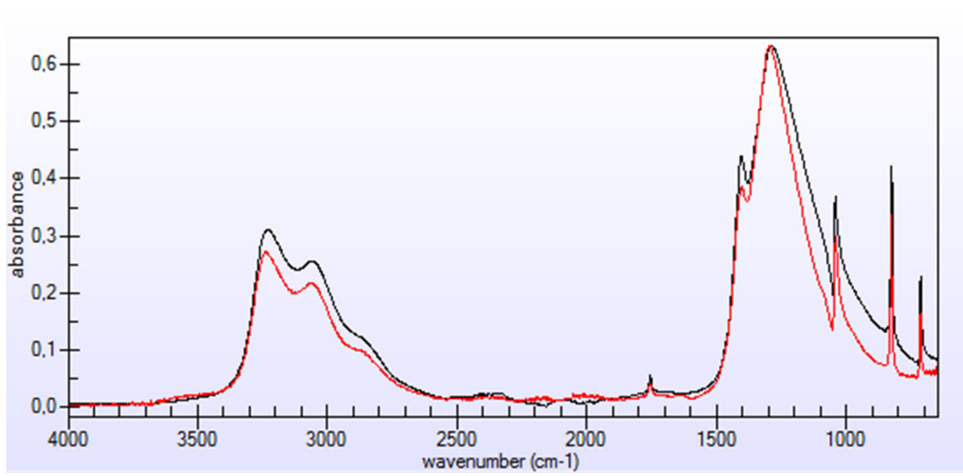

Fig. 7. Spectrogram of ammonium nitrate obtained after the process of neutralization

6. CONCLUSION

It is hereby presented an integrated technology for disposal of chemical waste. Compounds, obtained after chemical transformation of substances, classified as hazardous waste, prove that the hazardous properties of chemicals (subject to disposal) have decreased to such low levels that would not affect the environment. After disposal (neutralization) of the hazardous chemicals (waste) by this technology the obtained compounds are salts and their use in processes of production would be a good practice for their utilization.The developed integrated technology for the disposal of chemical waste, allows the treatment of various types of chemicals that are not addressed in this article. The system allows to change the components of the technology system depending on the type of disposal chemical (waste).

COMPETING INTERESTS

Author has declared that no competing interests exist.

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